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POTATO TUBER CONTENT OF MAGNESIUM AND CALCIUM DEPENDING ON WEED CONTROL METHODS

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Abstract

Studies were conducted on samples of potato tubers harvested in a field experiment carried out at Zawady Experimental Farm of the University of Natural Sciences and Humanities in Siedlce in 2005-2007. The experimental design was a randomised complete block in a split-plot arrangement with 2 cultivars (Irga and Balbina) as main plots, and 4 weed control technologies (with the following herbicides: Plateen 41.5 WG, Racer 250 EC and Sencor 70 WG) as subplots. There was also a control plot with no chemical control of weeds. The purpose of the study was to determine magnesium and calcium content in the dry matter of edible potato tubers depending on weed control methods based on some herbicides. Magnesium and calcium content in the dry matter of potato tubers was determined by the AAS method. The content of the elements depended significantly on cultivars, weed control methods and weather conditions during the growing season. The herbicides Plateen 41.5 WG and Sencor 70 WG significantly increased the magnesium content in the dry matter of the tubers of potato whose cultivation included weed control based on Racer 250 EC and control potato (only mechanical weed control). The highest magnesium content was determined in the tubers of potato sprayed with Sencor 70 WG (metribuzin) – 1.032 g kg^{-1}, on average. Moreover, the experimental herbicides increased the tuber contents of calcium compared with the control, by 0.016 g kg^{-1}, on average. There were determined different magnesium and calcium contents in the experimental cultivars. Balbina accumulated more and Irga less magnesium and calcium, on average 1.138 and 0.575 g kg^{-1} as well as 0.890 and 0.510 g kg^{-1}, respectively. Weather conditions in the study years significantly affected the potato tuber contents of magnesium and calcium.

Key words: magnesium, calcium, potato, herbicides.

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ZAWARTOŚĆ MAGNEZU I WAPNIA W BULWACH ZIEMNIAKA W ZALEŻNOŚCI OD ZABIEGÓW ODCHWASZCZAJĄCYCH

Abstrakt

Badania wykonano na próbach bulw ziemniaka pochodzących z doświadczenia polowego przeprowadzonego w latach 2005-2007 w Rolniczej Stacji Doświadczalnej Zawady, należącej do Uniwersytetu Przyrodniczo-Humanistycznego w Siedlcach. Eksperyment założono metodą losowanych podbloków. Czynnikami eksperymentu były: 2 odmiany ziemniaka jadalnego – Irga, Balbina i 4 sposoby pielęgnacji z uwzględnieniem herbicydów: Plateen 41,5 WG, Racer 250 EC, Sencor 70 WG oraz obiekt kontrolny bez ochrony chemicznej. Celem badań było określenie zawartości magnezu i wapnia w suchej masie bulw ziemniaka jadalnego w zależności od zabiegów odchwaszczających z uwzględnieniem niektórych herbicydów. Zawartość magnezu i wapnia w suchej masie bulw ziemniaka oznaczono metodą ASA. Zawartość pierwiastków zależała istotnie od odmian, sposobów zwalczania chwastów i warunków pogodowych w okresie wegetacji. Herbicydy Plateen 41,5 WG i Sencor 70 WG wpływały istotnie na zwiekszenie koncentracji magnezu w suchej masie bulw ziemniaka w odniesieniu do pielęgnacji z użyciem preparatu Racer 250 EC i obiektu kontrolnego (pielęgnacji mechanicznej). Największą zawartość tego makroskładnika stwierdzono w bulwach ziemniaka opryskiwanych herbicydem Sencor 70 WG (metribuzin) – średnio 1,032 g kg^{-1}. Ponadto stosowane w doświadczeniu herbicydy wpływały na zwiększenie koncentracji wapnia w odniesieniu do obiektu kontrolnego, przeciętnie o 0,016 g kg^{-1}. Badane odmiany różniły się istotnie pod względem zawartości magnezu i wapnia, i więcej tych składników gromadziły bulwy odmiany Balbina – odpowiednio 1.138 g kg^{-1} i 0,575 g kg^{-1}, a mniej odmiany Irga – średnio 0,890 g kg^{-1} i 0,510 g kg^{-1}. Warunki pogodowe w latach badań istotnie różnicowały zawartość magnezu i wapnia w bulwach ziemniaka.

Słowa kluczowe: magnez, wapń, ziemniak, herbicydy.

INTRODUCTION

Plant-derived food is the major source of nutrients for man. One of such plants is potato so potato tuber content of nutrients is very important (Boligłowa, Dzienia 1999, Nemutlu, Őzaltm 2005, Abulude et al. 2006).

Potato tubers contain 1-1.2% mineral compounds, the most basic being potassium, magnesium, calcium and phosphorus (Kolasa 1993). Macroelements perform important building functions, are an integral part of enzymes, and play an important role as regulators of metabolic processes (Stefańska et. al. 2003). A recommended daily intake of Mg and Ca by man is around 300-400 and 800-1000 mg, respectively (Hendrix et al. 1995). Both the shortage and excess of the elements result in disturbed metabolism in plants and animals (Szynal, Sykut 1992, Rivero et al. 2003). Magnesium and calcium contents in potato tubers are conditioned by varietal properties, soil, weather conditions during growth and agrotechnological practices, including weed control and mineral fertilization (Boligłowa, Dzienia 1999, Mazurczyk, Lis 2001, Tekalign, Hammer 2005, Gugała, Zarzecka 2009, Miles, Buchman 2009, Wichrowska et al. 2009). The literature on the subject reveals that the effect

of herbicides on minerals in potato tubers or cereal grains has not been fully explained and remains dubious (BRZOZOWSKA 2008, GUGAŁA, ZARZECKA 2009).

Hence, the purpose of this study was to determine magnesium and calcium contents in edible potato tubers depending on different weed control methods incorporating some herbicides.

MATERIALS AND METHODS

Potato tubers were harvested in a field experiment conducted at the Zawady Experimental Farm of the University of Natural Sciences and Humanities in Siedlce over 2005-2007. The experiment was set up on the soil of very good rye complex. Selected soil chemical properties prior to experiment set-up are presented in Table 1. The experimental design was a randomised complete block in a split-plot arrangement with 2 cultivars (Irga

Table 1

Chemical properties of the soil

Specification	2005	2006	2007
Organic matter (g kg^{-1})	11.5	11.3	14.0
Soil pH (1 M KCl)	6.74	5.50	4.99
Content of available nutrients (mg kg^{-1}):			
P	43.0	55.4	99.4
K	85.6	179.4	149.4
Mg	145.2	50.0	39.0

and Balbina, both mid-early cultivars) as main plots, and 4 weed control practices as subplots (Table 2). The herbicides were applied prior to potato plant emergence. The same farmyard manure amount of 25 t ha^{-1} was applied. Mineral fertilizers were applied at the following rates: 90 kg ha^{-1} N, 32.9 kg ha^{-1} P and 112.1 kg ha^{-1} K. The area of one plot was 25 m^2. Potatoes were harvested at the technological maturity stage in early September.

Potato tubers, later used for chemical analysis, were sampled from plots during harvest. Initially prepared samples (cleaned and mixed) were stored till analysed (for two days) in paper bags at the temperature of 18-20°C. Then, they were analysed for magnesium and calcium using atomic absorption spectrometry – AAS (AZCUE, MURDOCH 1994). The chemical analyses were performed on dry material in three replications. The material was washed in tap and then distilled water and ground down. Next, it was dried until a constant weight was reached initially at 70°C, and then 105°C. Dried potatoes (1.0 g of a sample) were ground and a mixture of HNO_3 (7 ml) and H_2O_2 (1 cm^3) was added. Then, the plant material was mineralised in

Table 2

Factors of the experiment

Factor I – Cultivars
1. Irga 2. Balbina
Factor II – Weed control methods
1. Control object – mechanical weeding until and after potato rising 2. Plateen 41.5 WG (metribuzin + flufenacet) 2.0 kg ha^{-1} 3. Racer 250 EC (fluorochloridon) 3.0 dm^3 ha^{-1} 4. Sencor 70 WG (metribzin) 1.0 kg ha^{-1}

a laboratory oven Ethos plus during 1 cycle (0.5 h). Following filtration, magnesium and calcium contents were determined. Mg and Ca contents are expressed as g kg^{-1} dry matter.

The results of the study were statistically analysed by means of variance analysis. Mean separation between variables was obtained by Tukey's test at the significance level of p=0.05. Weather conditions the growing seasons under study varied (Table 3).

Table 3

The mean temperature and rainfalls from April to September at Zawady in 2005-2007

Year	Meteorological conditions from April to September			
	rainfalls sum (mm)	in comparison to long term	mean temerature (°C)	in comparison to long term
2005	268.8	-2.3%	15.0	+2.0%
2006	358.6	+30.3%	15.8	+7.5%
2007	308.2	-12.0%	15.4	+4.8%
1987-2000	275.2	-	14.7	-

RESULTS AND DISCUSION

There are very few data in the literature concerning the influence of plant protection agents, including herbicides, on mineral contents in potato tubers (Abulude et al. 2006, Zarzecka et al. 2009).

Under the conditions of the experiment discussed, the dry matter of potato tubers contained between 0.875 and 1.149 g kg^{-1} magnesium (Tables 4, 5). There was found a significant effect of cultivars, weed control methods and weather and moisture conditions on magnesium concentration. Tuber content of magnesium was similar to the values reported by other authors (Bretzloff 1971, Yildrim, Tokusođlu 2005, Tekalign, Hammes 2005, Zarzecka et al. 2009).

Table 4

Content of magnesium in dry mass of potato tubers depending of cultivars (g kg^{-1} d.m.)

Weed control methods (II)	Cultivars (I)		Mean value
	Irga	Balbina	
1. The control object – mechanical weeding	0.877	1.124	1.001
2. Plateen 41.5 WG	0.900	1.147	1.024
3. Racer 250 EC	0.867	1.133	1.000
4. Sencor 70 WG	0.914	1.149	1.032
Mean	0.890	1.138	1.014
$LSD_{0.05}$ for:			
cultivar – I			0.024
weed control methods – II			0.029
interaction I x II			n.s.

n.s. – not significant

Table 5

Content of magnesium in potato tubers depending on years of study (g kg^{-1} d.m.)

Weed control methods (II)	Years (III)			Mean value
	2005	2006	2007	
1. The control object – mechanical weeding	1.039	0.875	1.088	1.001
2. Plateen 41.5 WG	1.072	0.895	1.104	1.024
3. Racer 250 EC	1.022	0.885	1.094	1.000
4. Sencor 70 WG	1.079	0.899	1.119	1.032
Mean	1.053	0.889	1.10	1.014
$LSD_{0.05}$ for:				
weed control methods – II				0.029
years – III				0.038
interaction II x III				n.s.

n.s. – not significant

The cultivars contained significantly different magnesium amounts; Balbina accumulated more and Irga less magnesium, on average 1.138 and 0.890 g kg^{-1}, respectively. Many workers (Karim et al. 1997, Gugała, Zarzecka 2009, Miles, Buchman 2009) have found that potato tuber chemical composition is primarily influenced by the genotype.

Plateen 41.5 WG and Sencor 70 WG significantly increased magnesium concentrations in potato tuber dry matter compared with Racer 250 EC and the control (mechanical weed control). The tubers of potato sprayed with Sencor 70 WG (metribuzin) contained most magnesium, on average 1.032 g kg^{-1}. Similar changes were reported by Zarzecka and Gąsiorowska (2000) who used herbicide mixtures to control weeds in potatoes, and Brzozowska (2008) who applied herbicides in winter wheat and examined its grain.

Calcium content in potato tuber dry matter was 0.543 g kg^{-1}, on average (Table 6). Similar tuber contents of this element were reported by KARIM et al. (1997), KOLBE and STEPHAN-BECKMANN (1997), ZARZECKA and GĄSIOROWSKA (2000). Statistical analysis confirmed that calcium content significantly depended on the weed control methods, cultivars and weather conditions in the study years.

Table 6

Content of calcium in potato tubers (g kg^{-1} d.m.)

Weed control methods (II)	Cultivars (I)		Mean value
	Irga	Balbina	
1. The control object – mechanical weeding	0.488	0.564	0.526
2. Plateen 41.5 WG	0.529	0.582	0.556
3. Racer 250 EC	0.507	0.574	0.541
4. Sencor 70 WG	0.514	0.581	0.548
Mean	0.510	0.575	0.543
$LSD_{0.05}$ for:			
cultivar – I			0.009
weed control methods – II			0.020
interaction I x II			n.s

n.s. – not significant

Herbicides increased calcium concentration compared with the control where no chemicals were applied, by 0.016 g kg^{-1}, on average. These findings agree with earlier studies by ZARZECKA et al. (2002). What is more, in the study by GUGAŁA and ZARZECKA (2010), the herbicides they applied in field pea cultivation increased seed contents of calcium compared with the control. By contrast, BRZOZOWSKA (2008) demonstrated that crop protection chemicals – herbicides – had no significant effect on calcium concentration in winter wheat grain.

The genetic traits of the cultivars significantly determined calcium contents. More calcium was accumulated by Balbina than Irga, on average 0.575 g kg^{-1} and 0.510 g kg^{-1}, respectively. The cultivars responded with an increased tuber content of calcium to the herbicides applied, however, there was found no interaction between the experimental factors. The influence of cultivar on calcium concentration has been reported by TEKALIGN and HAMMES (2005), MILES and BUCHMAN (2009), ZARZECKA et al. (2009).

According to BAĆMAGA et al. (2007), pesticides applied under field conditions to protect crops do not usually influence macroelements contents in plants, but it is easier for a crop plant to take up more individual nutrients when there is no competition with weeds.

In general, weather conditions in the study years significantly influenced magnesium and calcium contents in potato tuber dry matter (Tables 5,7).

Table 7

Content of calcium in potato tubers depending on years of study (g kg^{-1} d.m.)

Weed control methods (II)	Years (III)			Mean value
	2005	2006	2007	
1. The control object – mechanical weeding	0.558	0.447	0.574	0.526
2. Plateen 41.5 WG	0.594	0.469	0.605	0.556
3. Racer 250 EC	0.577	0.458	0.587	0.541
4. Sencor 70 WG	0.582	0.465	0.597	0.548
Mean	0.578	0.460	0.591	0.543
$LSD_{0.05}$ for:				
weed control methods – II				0.020
years – III				0.015
interaction II x III				n.s.

n.s. – not significant

Less magnesium and calcium were accumulated in 2006, when the weather was wet and warm, and more in 2005 and 2007, when the temperature was moderate and the rainfall was quite evenly distributed. The works by Zarzecka and Gąsiorowska (2000) as well as Wadas et al. (2008) have confirmed that there is an effect of weather conditions on magnesium and calcium contents

CONCLUSIONS

1. The herbicides Plateen 41.5 WG and Sencor 70 WG significantly affected the potato tuber dry matter contents of magnesium and calcium. In turn, Racer 25 EC had less impact, in particular on magnesium concentration.

2. Varietal traits influenced the concentration of both the elements. More magnesium and calcium in tuber dry matter was determined in Balbina compared with Irga.

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